DISSOLVER OFF-GAS FILTRATION

A. G. Blasewitz
General Electric Co., Richland, Wash.

I. INTRODUCTION

In the Separations process the irradiated metal, after a suitable "cooling" period is charged to the dissolver, or the first processing vessel. Here the jackets are removed and the uranium is dissolved. The dissolver vent gases during actual metal dissolution and the agitation and transferring of the prepared solution constitute the most highly contaminated gas stream in the Separations Plants. From the health-hazard viewpoint there are two principal contaminants, radio-iodine and an aerosol composed of other fission products. One of the primary problems in the decontamination of the stack gases at Hanford Works has been the development of methods and equipment to remove effectively the radio-active iodine and particulate contamination from the dissolver off-gas streams. The investigation has led to the development and adoption of the silver reactor and Fiberglas filter for iodine and particulate matter removal respectively. Today's discussion will be concerned primarily with the filtration of these process gas streams.

I. BACKGROUND

(A) Collector Requirements

The first slide presents the specifications which were established as representing the development and design goals for a dissolver off-gas filter.

FILTER SPECIFICATIONS

1. A collection efficiency of 99.99% for sub-micron particles present in low concentrations.
2. A life expectancy in terms of years.
3. A minimum of maintenance in the continuous operation of the unit.

4. No subsequent problem caused by the disposal of the collected material.

(B) Development Program

The success of the sand filter installations at Hanford led to the investigation of employing the same filtration mechanism, but with filter media of more desirable properties. It was suggested by Mr. C.E. Lapple, a consultant at Hanford from the Du Pont Company, during the summer and fall of 1948, that the substitution of glass fibers for sand might lead to some improvements in filter design and operation. Since the results of preliminary tests were favorable, an extensive investigation of the filtration characteristics of glass fibers was initiated.

This investigation consisted of three parts: (1) The correlation of collection efficiency and pressure drop under startup conditions with superficial air velocity, the bed depth, and the packing density of the various types of glass fibers; (2) A study of the manner in which the pressure drop of glass fibers increases with accumulative amount of smoke particles passing to the unit; and (3) A study of the physical characteristics of the glass fibers.

The investigation of the filtration characteristics of glass fiber beds was made under fixed conditions by employing the radioactive aerosol discharged from the process cells. It was determined that the two dependent variables, collection efficiency and pressure drop, could be mathematically expressed by the transfer unit concept. The efficiency equation is presented in the next slide:

Slide No. 2

TRANSFER UNIT EQUATION FOR FIBERGLAS FILTRATION

$$\text{Efficiency} = \frac{1 - \text{Wt. Passing Through Collector}}{\text{Wt. to Collector}}$$

$$= 1 - e^{-Nt}$$

$$= 1 - e^{-KL^a p^b / V^c}$$

where: L is bed depth, inches
p is packing density, lbs/ft^3
V is superficial velocity, ft/min
K is proportionality constant
a,b,c, are empirically determined exponents

The constants a, b, and c, must be obtained experimentally for each fiber. This was done by varying only one parameter at a time and obtaining the corresponding change in collection efficiency. The manner of handling the data is indicated on the next slide.

Slide No. 3

DATA CORRELATION

$$\text{Eff} = 1 - e^{-KL^a p^b / V^c}$$

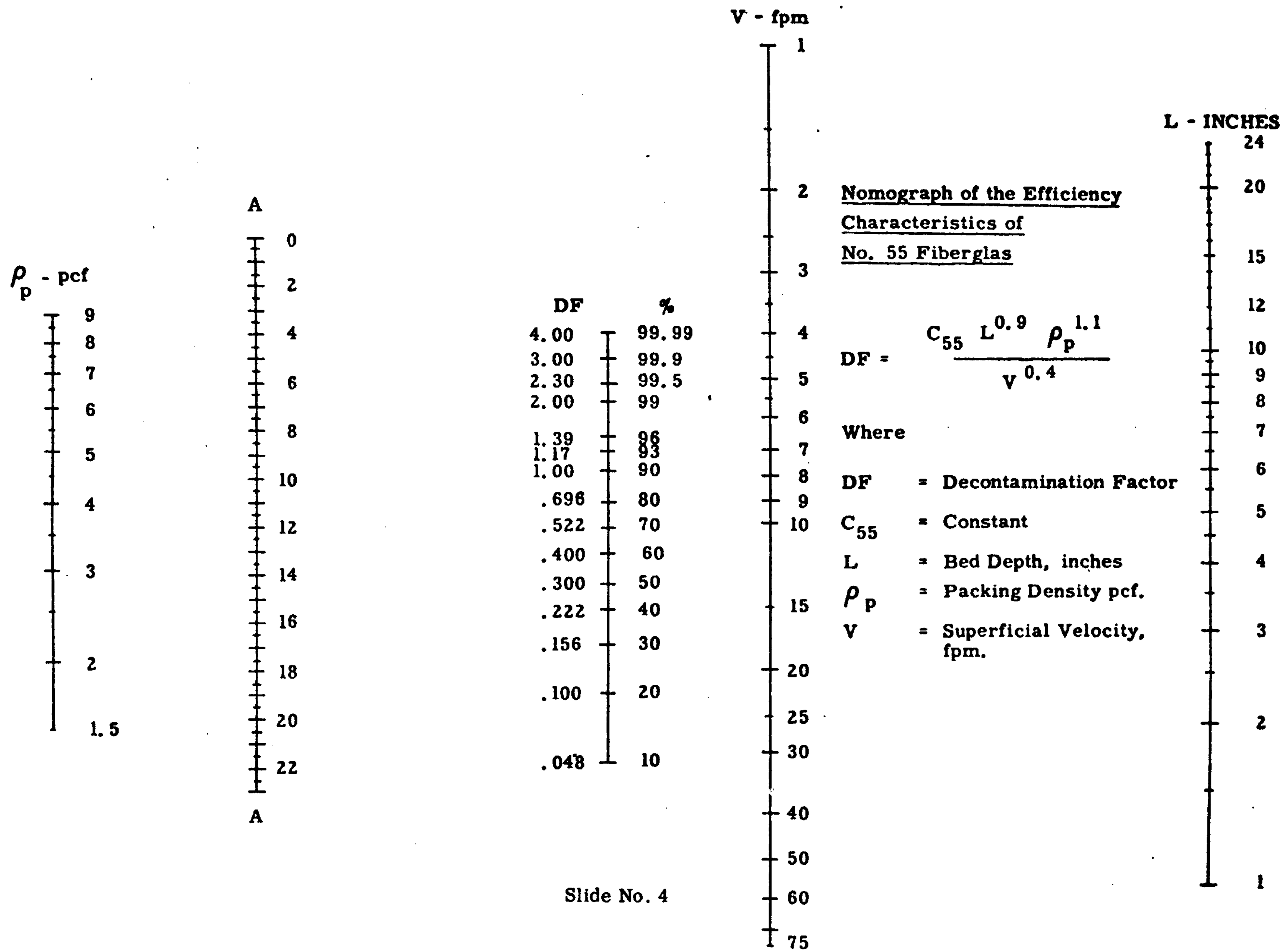
$$1 - \text{Eff} = e^{-K'L^a}$$

$$\log (1 - \text{Eff}) = -K'L^a \log e = -K'L^a$$

$$\log (- \log (1 - \text{Eff})) = a \log L + \log K''$$

If the "one" in the basic filtration equation is transposed and then the logarithm of both sides of the equation is taken twice, an expression is obtained stating the variation of efficiency with bed depth only. The "K" prime lumps the logarithm of all the constants in the equation. In the log-log plot of log (1 - efficiency) against the bed depth, the constant "a" is then the slope of the line obtained. The other constants "b" and "c", can be obtained in the same way by varying only the velocity or packed density respectively. The more promising glass fibers were thoroughly evaluated in this manner and the data assembled for each type of Fiberglas in nomograph form. A typical nomograph is shown in the next slide. This represents a compilation of the data for the so-called "Owens-Corning No. 55 Fiberglas". The nomograph makes it possible to predict the initial filtration efficiency of any filter bed of No. 55 Fiberglas at all packing densities and over a wide range of air velocities. In a composite filter bed where more than one grade of Fiberglas may be used, the initial efficiency of the part of the filter consisting of No. 55 Fiberglas can be readily predicted from the nomograph.

A couple of examples will show how this nomograph is used. Suppose we want to know the filtration efficiency of a 24-inch bed of 55 Fiberglas packed to a density of three pounds per cubic foot and operated at 25 feet per minute. You connect 3 on the fiber density scale with 25 on the velocity scale. The point where this line crosses the auxiliary line "A" is then connected to 24 on the bed depth scale. The efficiency of the unit, 96%, is then read off the efficiency scale. Another example would be to find what depth of 55 Fiberglas packed at six pounds per cubic foot is required to get a filtration efficiency of 96 per cent at a velocity of 25 feet per minute. Again a line is drawn from 6 on the packing density scale to 25 on the velocity scale. The point where this line crosses the "A" line is then connected to 96 on the efficiency line and extended to the bed depth line. We find that a bed depth of 11 inches is required.



Nomograph of the Efficiency Characteristics of No. 55 Fiberglas

$$DF = \frac{C_{55}\ L^{0.9}\ \rho_p^{1.1}}{V^{0.4}}$$

Where

DF	=	Decontamination Factor
C_{55}	=	Constant
L	=	Bed Depth, inches
ρ_p	=	Packing Density pcf.
V	=	Superficial Velocity, fpm.

Slide No. 4

Nomographs were also prepared for the various fibers relating pressure drop to the same variables. The nomographs are sufficiently accurate within the indicated ranges to be of particular value in the design of fibrous filters for the removal of particles similar to those at Hanford. These charts should also be of considerable use in any application where the particle loading is low.

The second phase of the investigation was concerned with the expected service life of glass fiber filters. The tests were conducted with a methylene blue smoke having a particle size distribution similar to that of the radioactive aerosol and a dust loading ten to twenty times that of the process cell air. Studies were made on several small depths of fibrous materials to investigate the course of the pressure drop increase which occurs with the passage of smoke particles to a fixed bed filter. By including a less efficient filter that effectively protects the more efficient material the life expectancy of the composite filter can be extended. In the series of methelyne blue tests, a comparison was made of the useful filtration life to be expected from the various types of fibrous units. At the same time suitable fore-filters were developed for the more efficient glass fibers.

The final phase of the investigation was primarily concerned with the weatherability of glass fibers; that is, the degree to which the various types of fibers can withstand the effects of water, alkali, or acid present in the gas stream passing through the filter bed. This information was assembled to permit the specification of glass fibers having the maximum weatherability for particular service conditions.

III. PLANT INSTALLATIONS

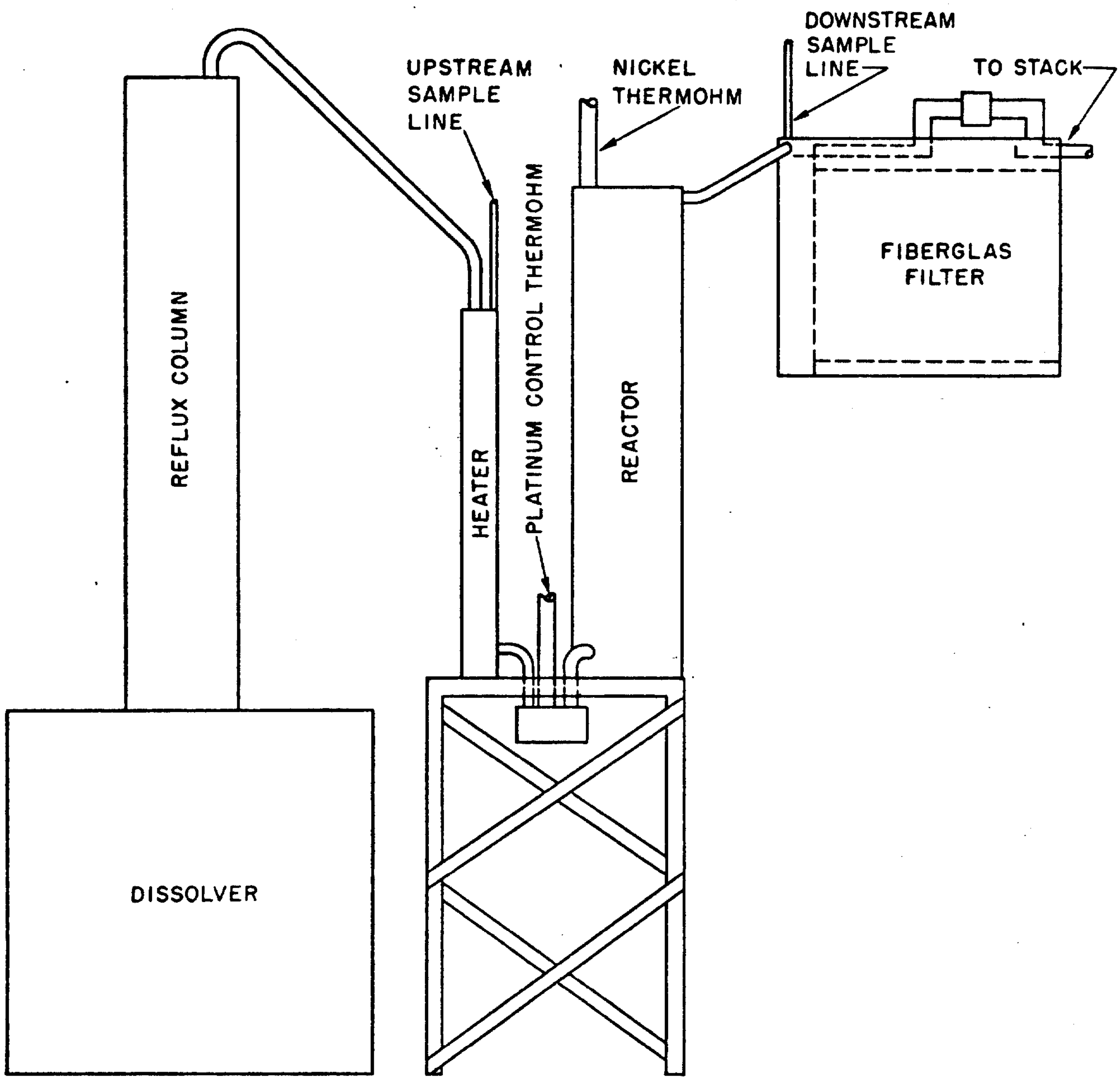
(A) Equipment Description

The development and design of the silver reactor for iodine removal proceeded concurrently with the filtration studies. Silver reactors and Fiberglas filters were installed in the dissolver cells as integral decontamination units. The first assembly was placed in operation on October 26, 1950. The next slide presents a schematic representation of the equipment. The assembly consists of a heater, a reactor tower containing a silver bearing material, and a Fiberglas filter. The dissolver vent gases after leaving the reflux column are passed through the heater where the temperature is adjusted to the value desired for the reaction between the iodine in the gas stream and the silver bearing packing. The iodine reacts with the silver to form silver iodide and is retained within the bed. The gases then pass through the Fiberglas filter for particulate decontamination and are discharged to the stack. Monitoring of the gases downstream from the reactor has established that the plant silver reactors are removing iodine from the dissolver vent gases with an efficiency greater than 99.99 per cent.

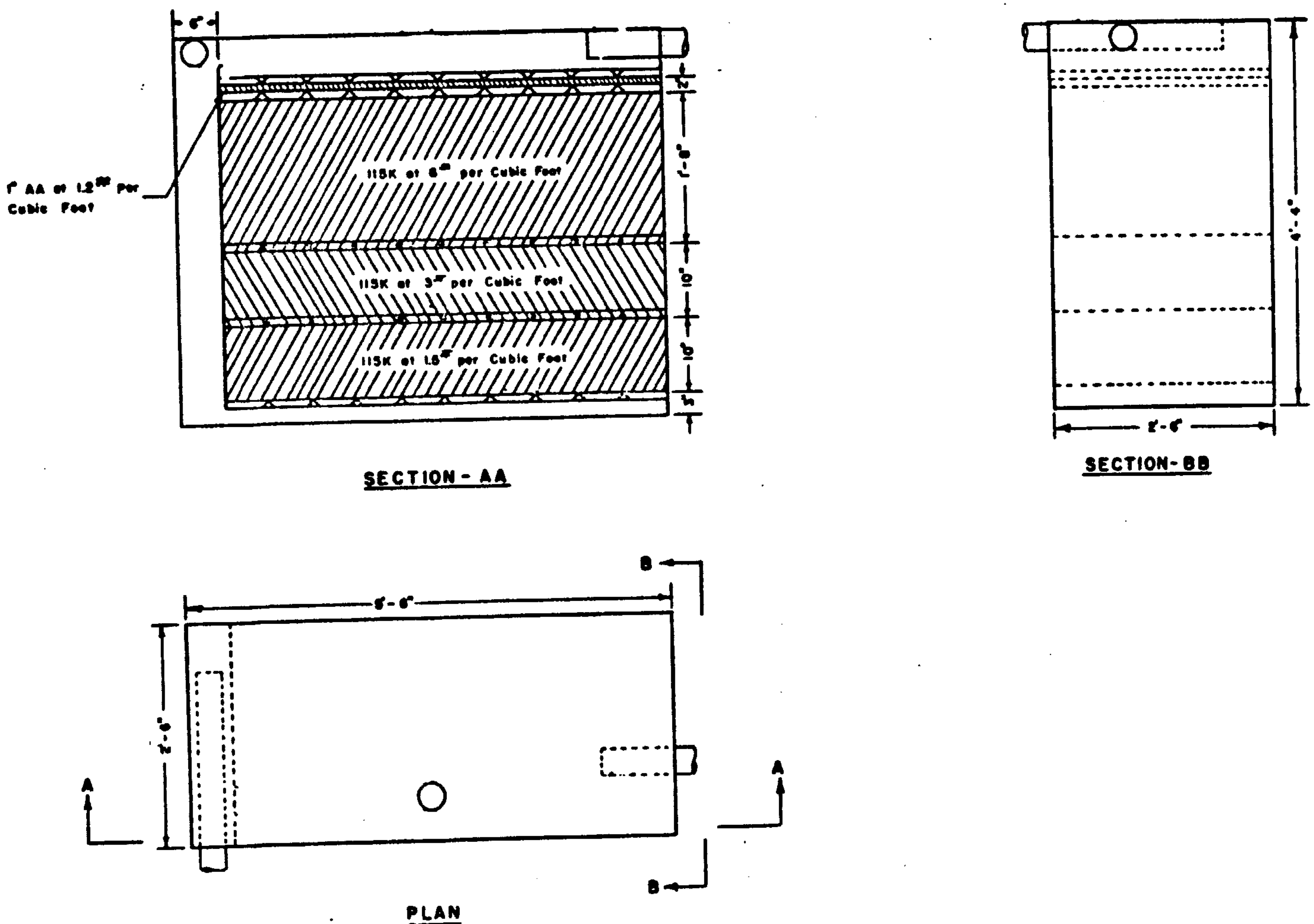
The dimensional details of the dissolver cell Fiberglas filter are presented in the next slide. The unit is 2-1/2 feet by 5-1/2 feet with an overall height of 4.3 feet. The cross-sectional area, 12.5 square feet, results in a superficial velocity of approximately 20 feet per minute under conditions of maximum gas flow. Weatherability data indicated that the chemical resistivity of the 115K and AA Fiberglas would be satisfactory under the service conditions. The depth and packing densities of the various strata were selected to provide a maximum service life, a filtration efficiency in the order of 99.99 per cent, and a pressure drop of 4 inches of water at the rated air velocity.

Performance Data

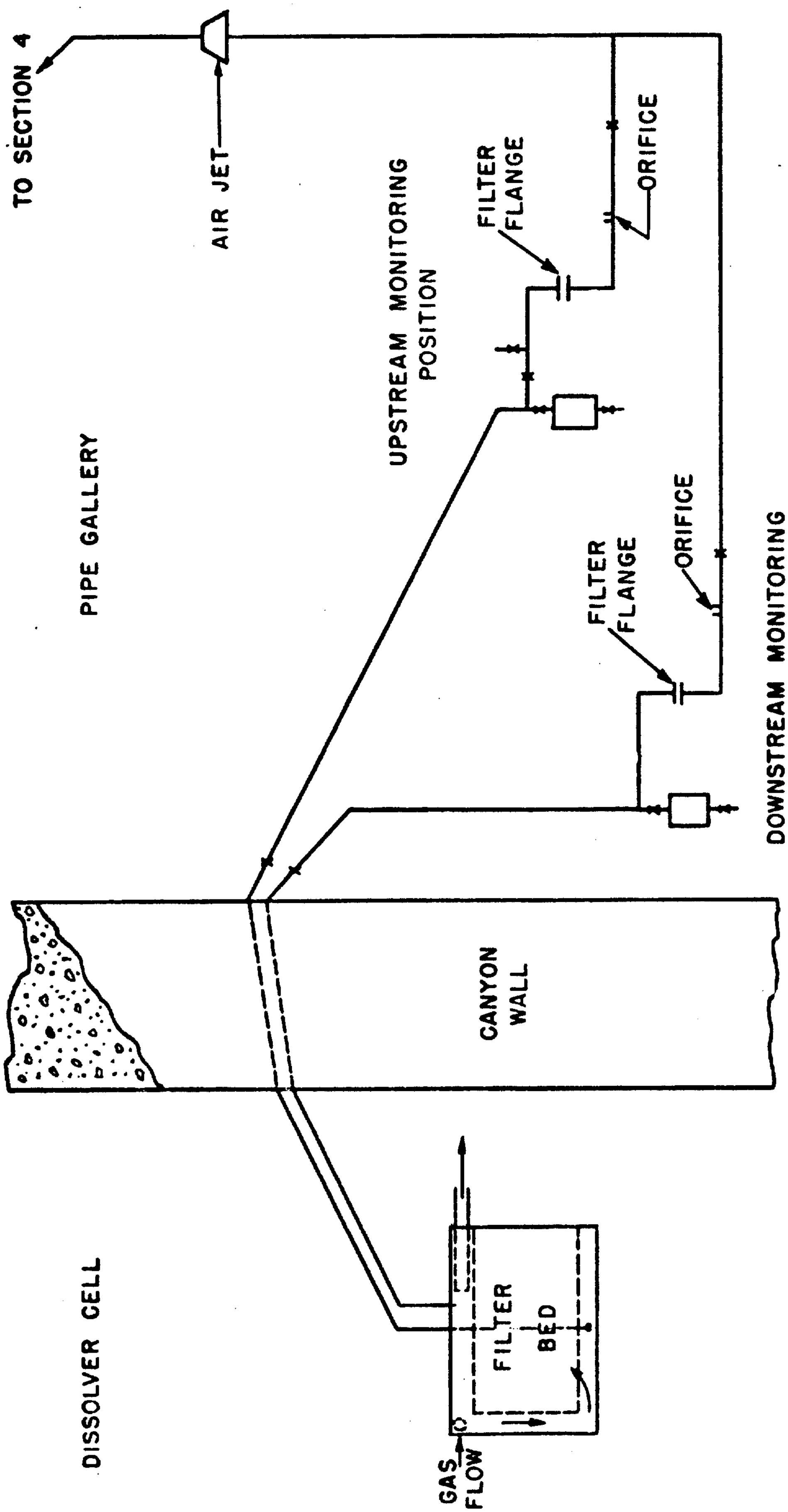
To obtain accurate efficiency data for the Fiberglas filter, monitoring equipment was installed in the Canyon Building pipe gallery. The system is schematically represented in the next slide. Aliquots of the upstream and downstream gases were drawn through the filter pressure lead lines, through the canyon wall and passed through CWS Type 6 monitoring filters. The system used short, well-sloped lines and permitted reliable sampling. The data which were



Slide No. 5—Schematic diagram of silver reactor – fiberglas unit.



Slide No. 6—Dissolver cell fiberglas filter.



Slide No. 7 — Fiberglas filter monitoring equipment 221-B pipe gallery.

obtained with this apparatus are presented in the next slide.

Slide No. 8

FIBERGLAS FILTER MONITORING DATA

	Upstream Monitor		Downstream Monitor		
Date	Flow (cfm)	Mrep/hr.	Flow (cfm)	Mrep/hr.	Efficiency (%)
12-19-50	1.0	6000	1.0	<5	>99.92
12-19-50	1.0	1500	1.0	<5	>99.67
12-21-50	1.0	4250	1.0	<5	>99.88
12-21-50	1.0	33000	1.0	8	99.97
12-21-50	0.5	9750	1.5	<5	>99.98
12-22-50	0.5	6000	3.0	<5	>99.98
12-22-50	0.5	135	3.0	<5	>99.39

In this efficiency range, with only approximately one part in 10,000 passing the filter it is quite difficult to obtain definitive efficiency values. Even with the expedient of using different flow ratios through the two monitors it is difficult to obtain a set of monitoring filters for which the upstream sample is not too "hot" or the downstream sample too "cold" for accurate activity readings. Consequently, a majority of the efficiency determinations can be expressed only as "greater than" values. The data demonstrate, however, that the efficiency of the Fiberglas bed is greater than 99.9 per cent and probably near 99.99 per cent. The efficiency values obtained agree well with the calculated design figures.

The first filter units have been in operation for slightly less than two years. There have been no maintenance requirements nor has there been any change in operating characteristics.